Geophysical Research Abstracts
Vol. 15, EGU2013-329-1, 2013
EGU General Assembly 2013

Diffusion length history over the last 16 ka based on a high resolution δ^{18}O record from NGRIP. Implications for glaciological and paleoclimatic studies.

Vasileios Gkinis (1,2), Sebastian B. Simonsen (2), Susanne L. Buchardt (2), Bo M. Vinther (2), and James W. C. White (1)

(1) University of Colorado, Institute for Arctic and Alpine Research, United States (v.gkinis@nbi.ku.dk), (2) Center for Ice and Climate, University of Copenhagen

The Holocene epoch as seen in the water isotopic records of polar ice cores is described by a relatively stable climate characterized by minimal fluctuations in temperature. Arguably, the most commonly used proxy in ice core studies, the ratios of water's stable isotopes, provide an insight in past temperatures via a linear relationship with temperature, commonly referred to as the isotope slope. However, the validity of this slope has been extensively debated. Based on borehole thermometry and gas isotope fractionation studies, it has been shown that temperature changes over the Bølling – Allerød and Younger Dryas transitions as well as several interstadial events have been underestimated by the water isotope slope. Additionally, isotopic artifacts related to ice sheet elevation changes, apparent between 6 and 10 ka b2k, result in a poor or even absent representation of the Holocene climatic optimum in the δ^{18}O record from Greenland ice cores, contrary to what other paleoclimatic records from Northern latitudes indicate.

In this study we present ongoing work on the use of the firn isotopic diffusion lengths as a high resolution proxy of the snow and firn temperature. Our reconstruction is based on the high resolution δ^{18}O dataset from NGRIP. Water isotope diffusion is a process that occurs after deposition of the precipitation and takes place in the porous space of the firn until the close off depth. Assuming a diffusivity parameterization and based on a densification and strain rate history, it is possible to investigate the effects of temperature and accumulation on the diffusion length.

By inverting the model we produce a temperature reconstruction for the last 15 ka. This temperature signal is independent of factors like the water vapor source location and temperature, the intensity of the atmospheric inversion over the deposition site and the presence or not of clear sky precipitation. In order for the reconstruction to reproduce the long term climate signal, a correction for the thinning function is required. Under the assumption that the GICC05 chronology is the best available estimate for the age – depth relationship in the ice, that would require about 10 – 15% lower accumulation rates at the time of the climatic optimum.

The temperature reconstruction is able to infer a Younger Dryas warming signal very close to what previous borehole thermometry and gas isotope fractionation studies indicate. A strong 8.2 ky event can be seen in the record and seems to occur in a two stage fashion and last longer than the raw δ^{18}O signal indicates. Overall, the inferred temperature signal reveals a significant variance with climatic events that are initially not reflected in the δ^{18}O record. Some of those events are supported by the findings of other northern hemispheric climatic or historical records (Medieval and Roman warm periods). The most profound of those events is a rapid warming occurring between 4 and 5 ky b2k, indicating a clear mid – Holocene optimum and ending with a rapid cooling at approximately 4.2 ky b2k. We will comment on the validity of those results as well as the feasibility of the magnitude of the temperature shifts and propose ways to constrain the findings further.